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Melsheimer

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(54) **DIRECT PULLBACK DEVICES AND METHOD OF HORIZONTAL DRILLING**

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This patent is subject to a terminal disclaimer.

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E21B 10/60 (2006.01)
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See application file for complete search history.

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Primary Examiner — David J Bagnell

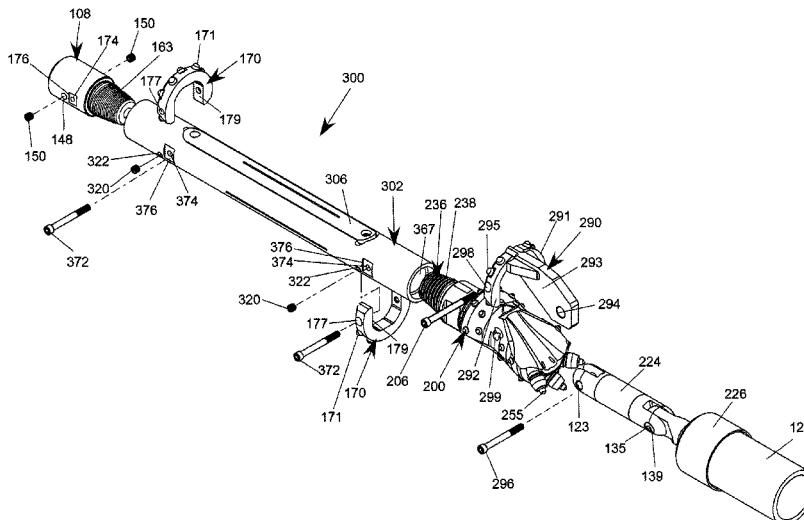
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(57) **ABSTRACT**

An apparatus for horizontal directional drilling includes a housing and a sonde transmitter mounted in the housing. The housing includes a main fluid channel to permit a flow of a fluid therethrough. The apparatus further includes a fluid outlet at the front of the housing in communication with the main fluid channel and adapted to emit fluid from the front of the housing during pilot bore operations. The housing further includes a plurality of fluid ports in fluid communication with the main fluid channel and adapted to emit fluid from the housing during pullback operations. Drill bits, drill bit adapters, swivel connectors, and tow heads adapted to be coupled to the drill bits for direct pullback operations, as well as methods of direct pullback operations during horizontal direction drilling are also provided.

20 Claims, 13 Drawing Sheets



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<i>E21B 7/04</i> (2006.01)
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| (52) | U.S. Cl.
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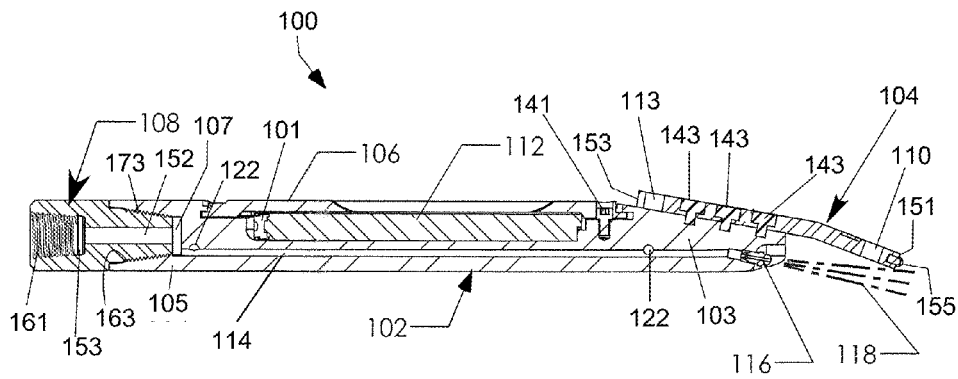
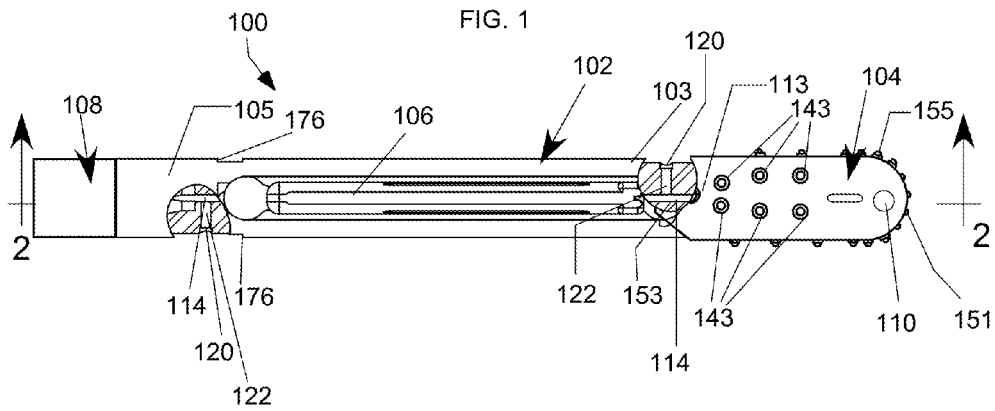
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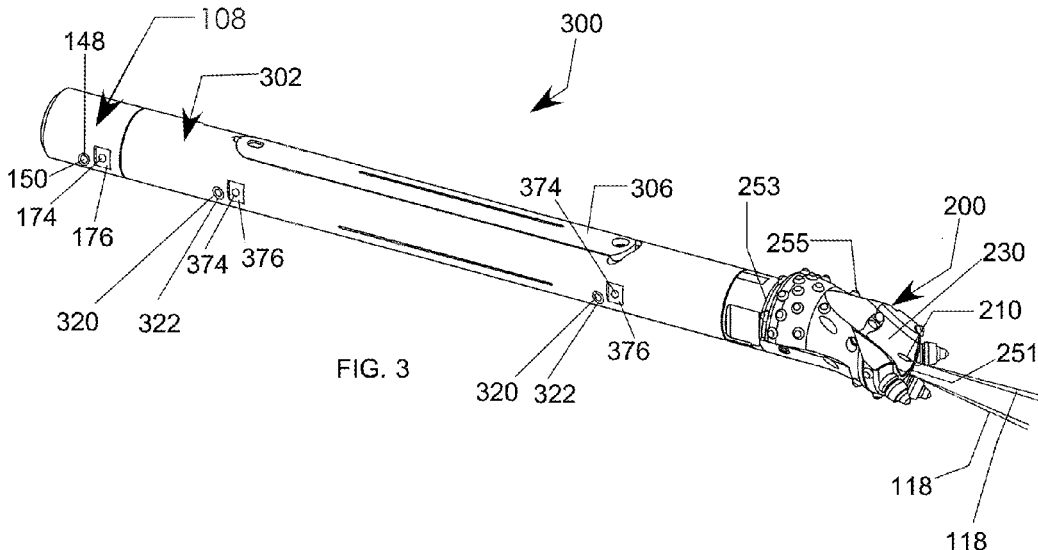
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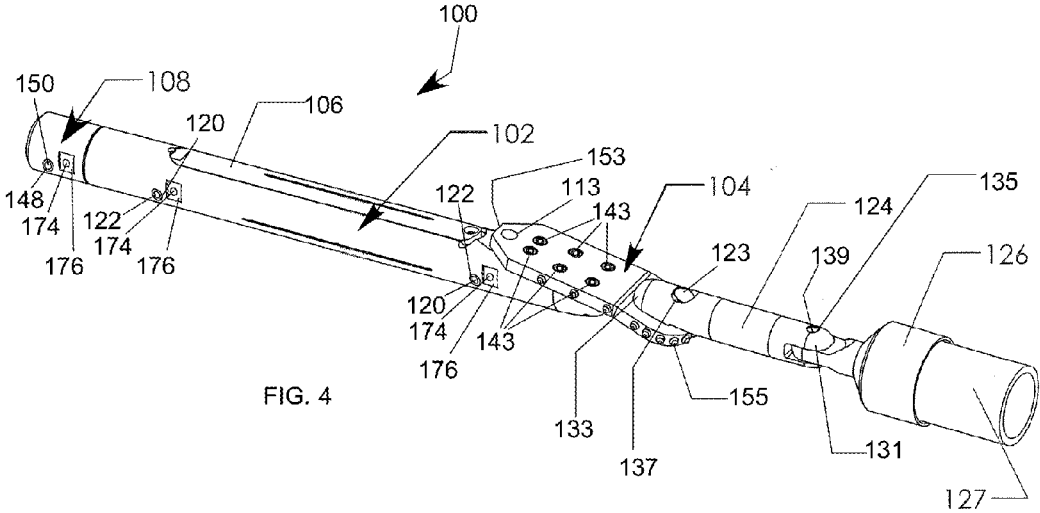


FIG. 4

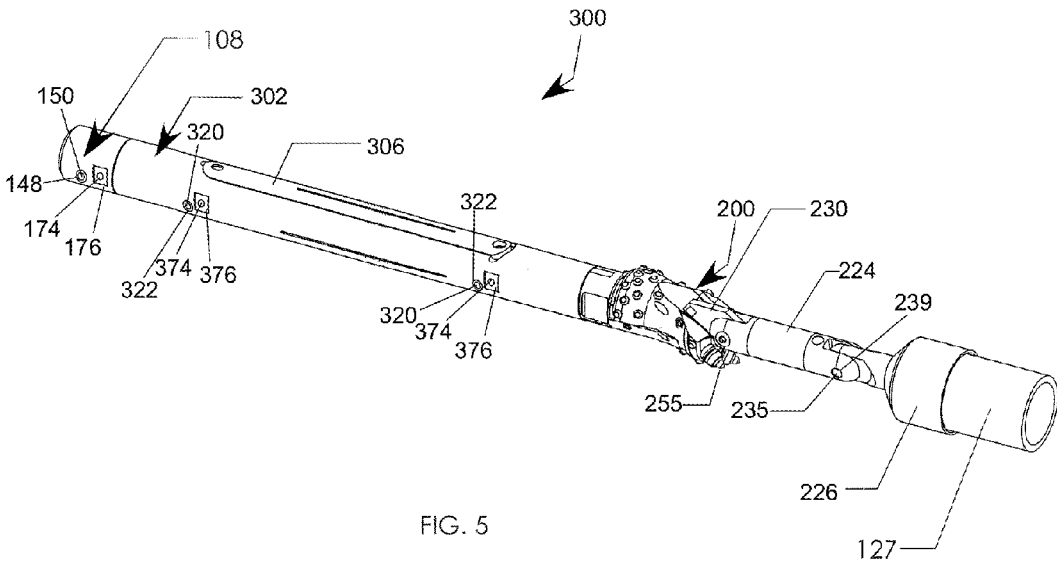
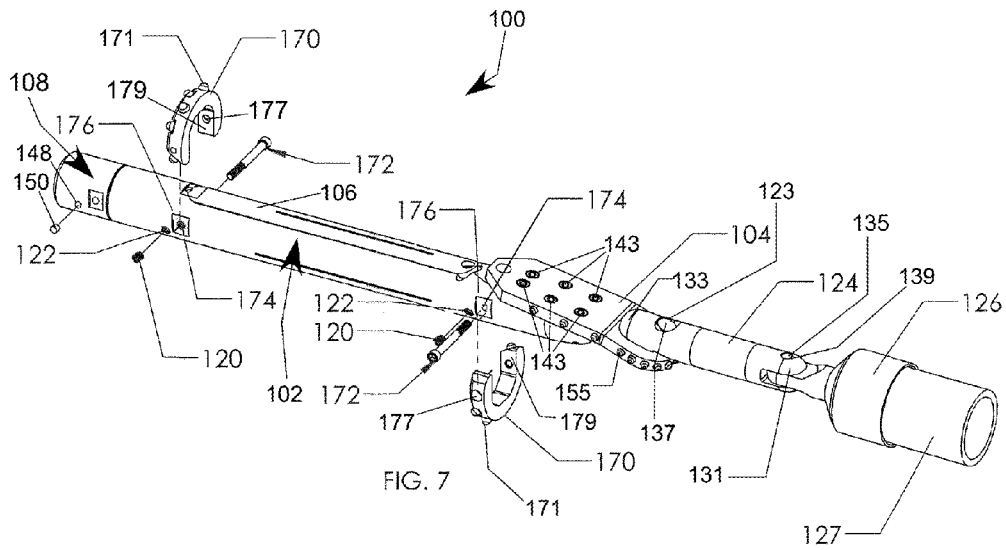
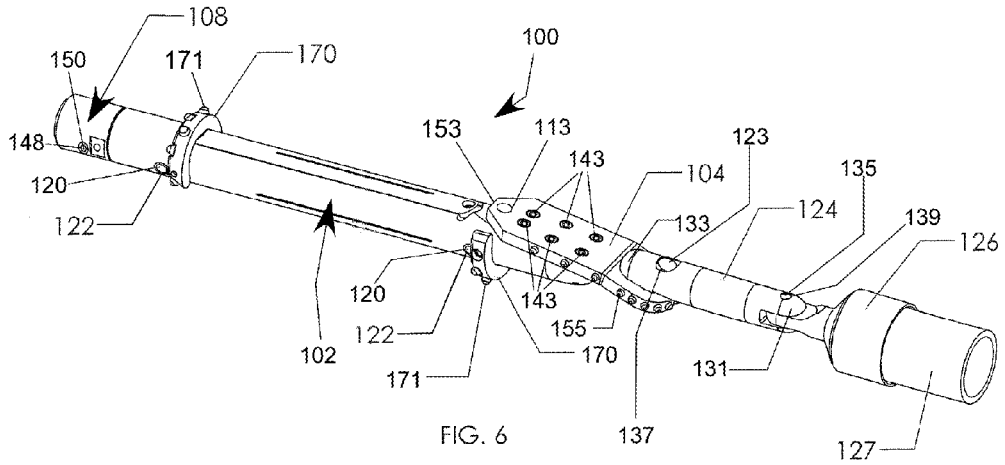


FIG. 5



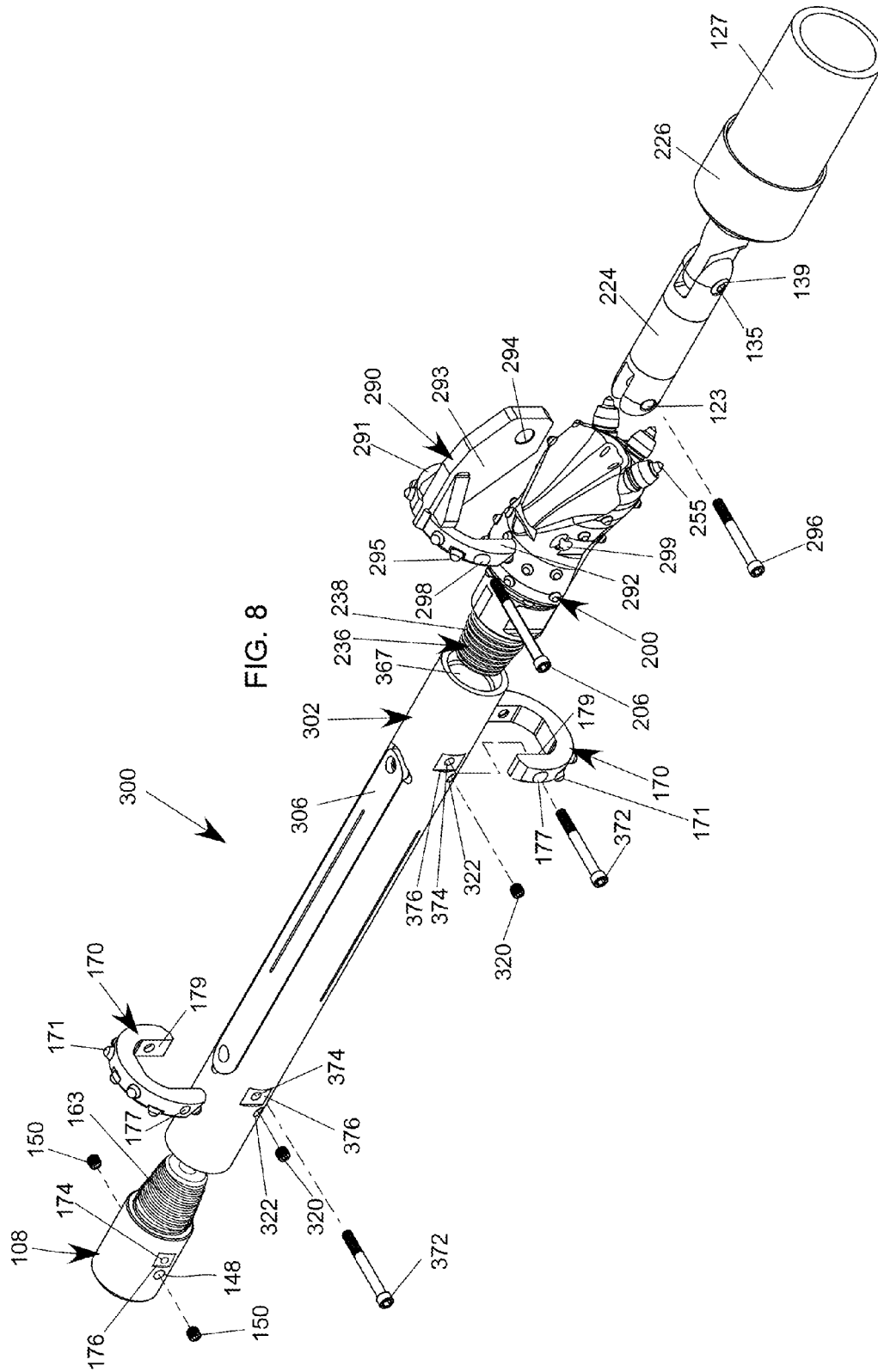


FIG. 8

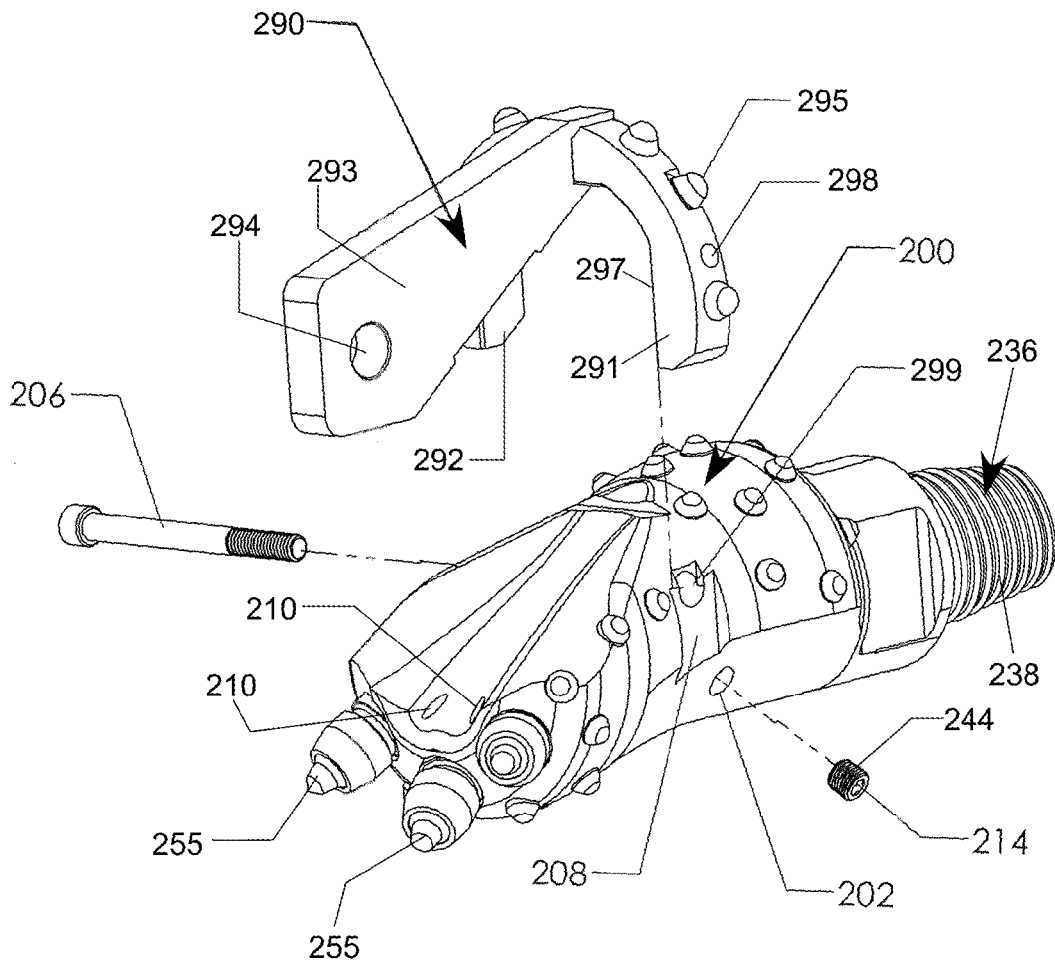


FIG. 9

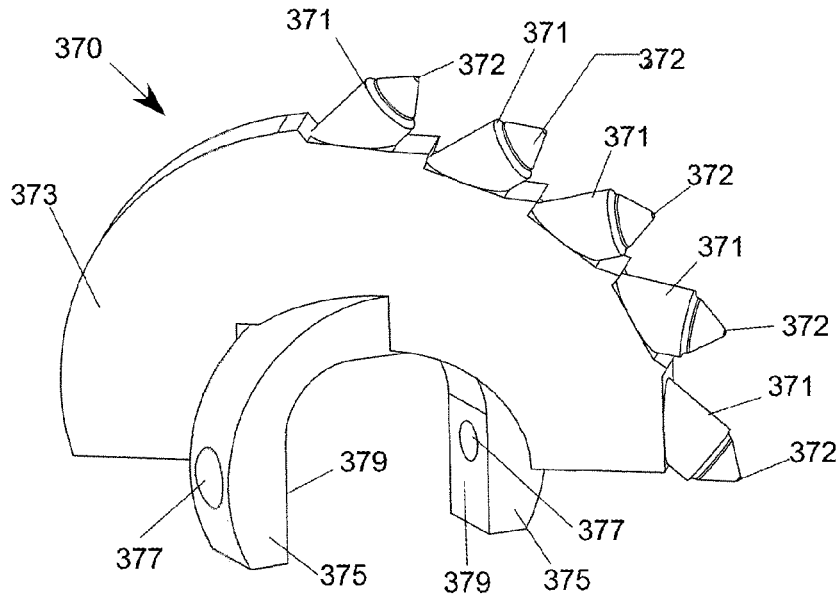


FIG. 10

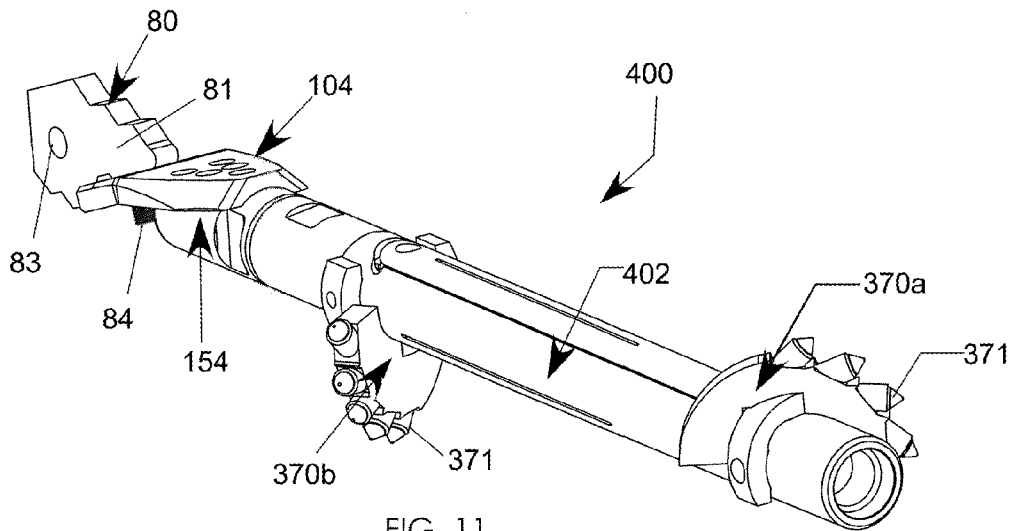
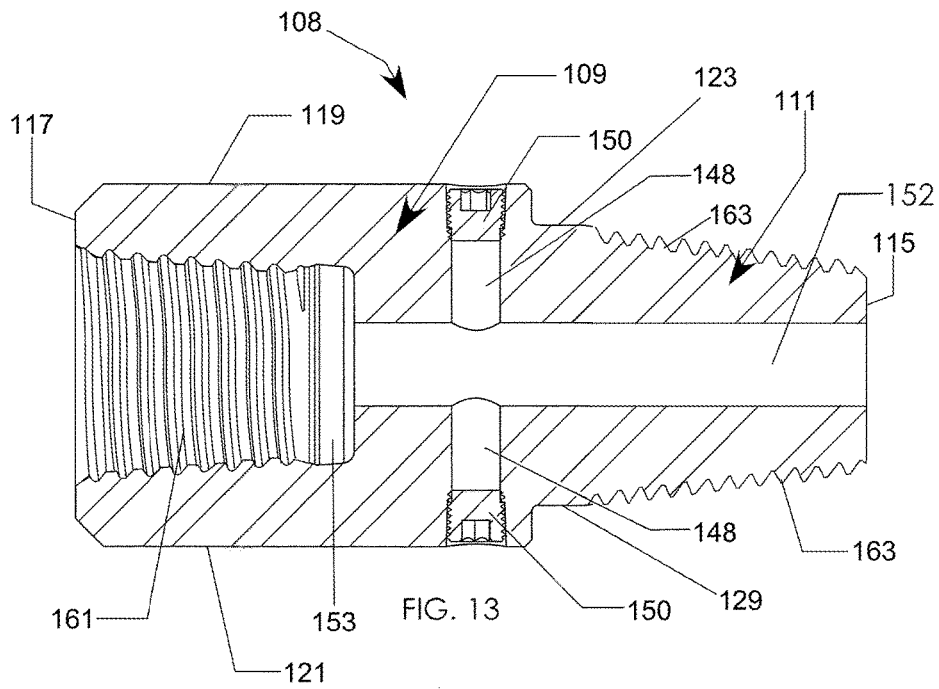
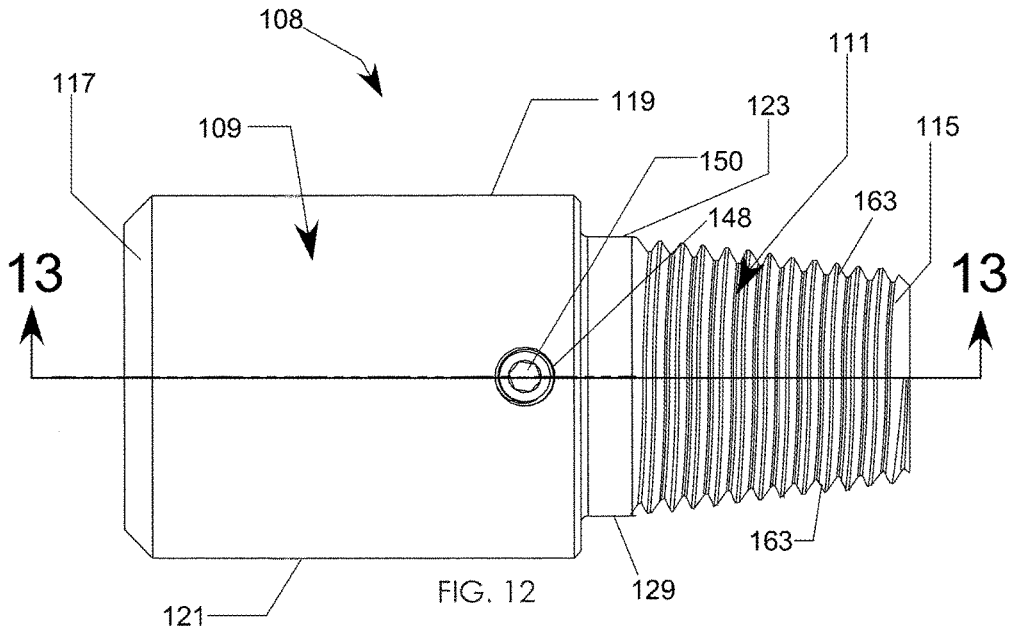


FIG. 11



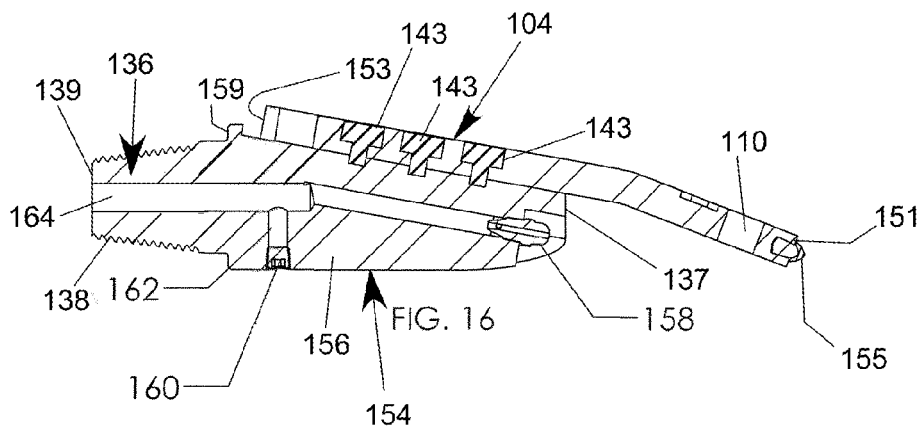
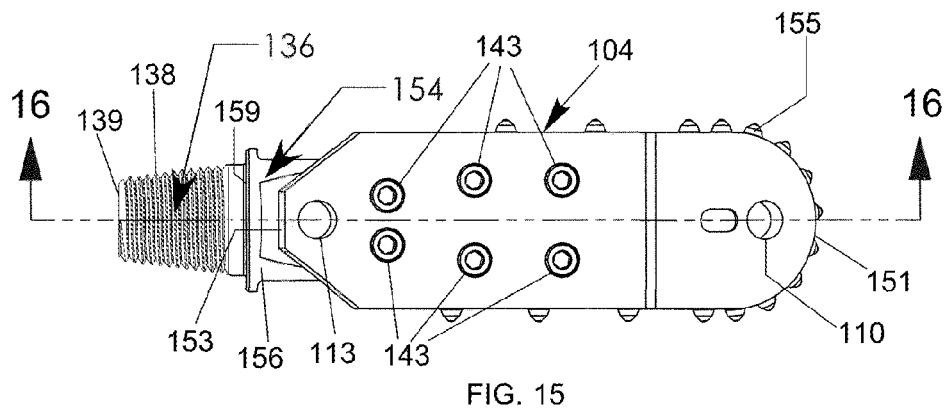
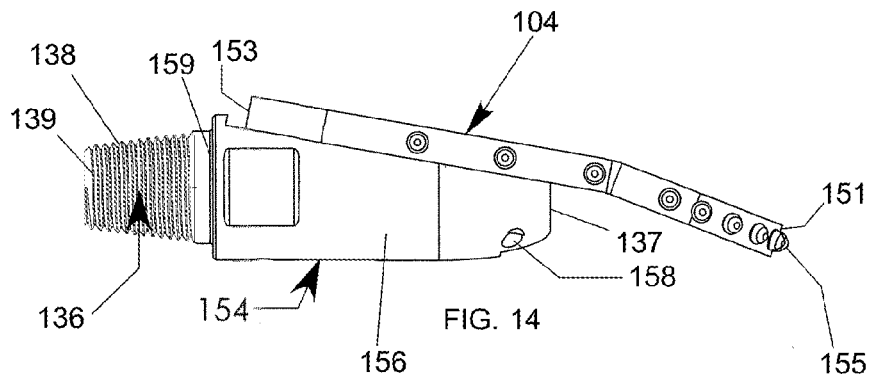


FIG. 19

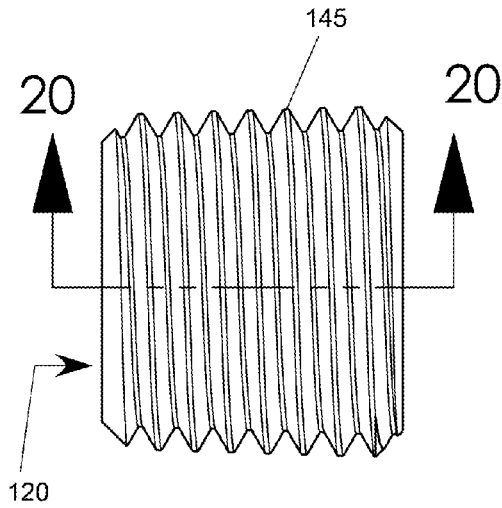


FIG. 20

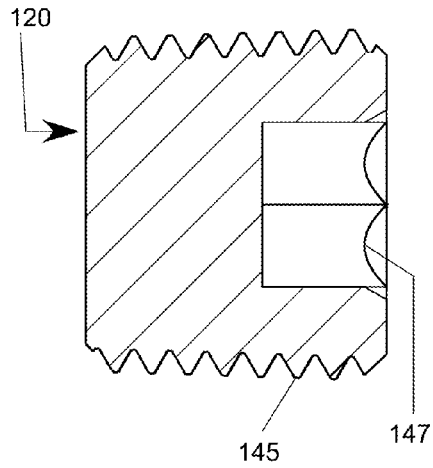


FIG. 21

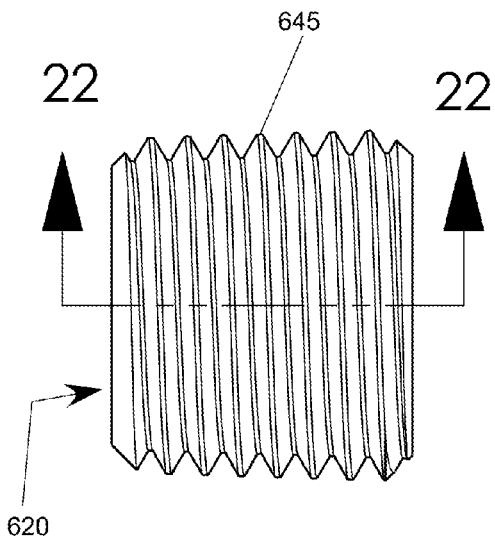
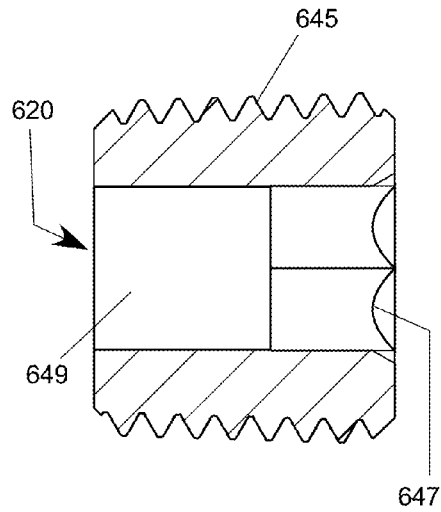
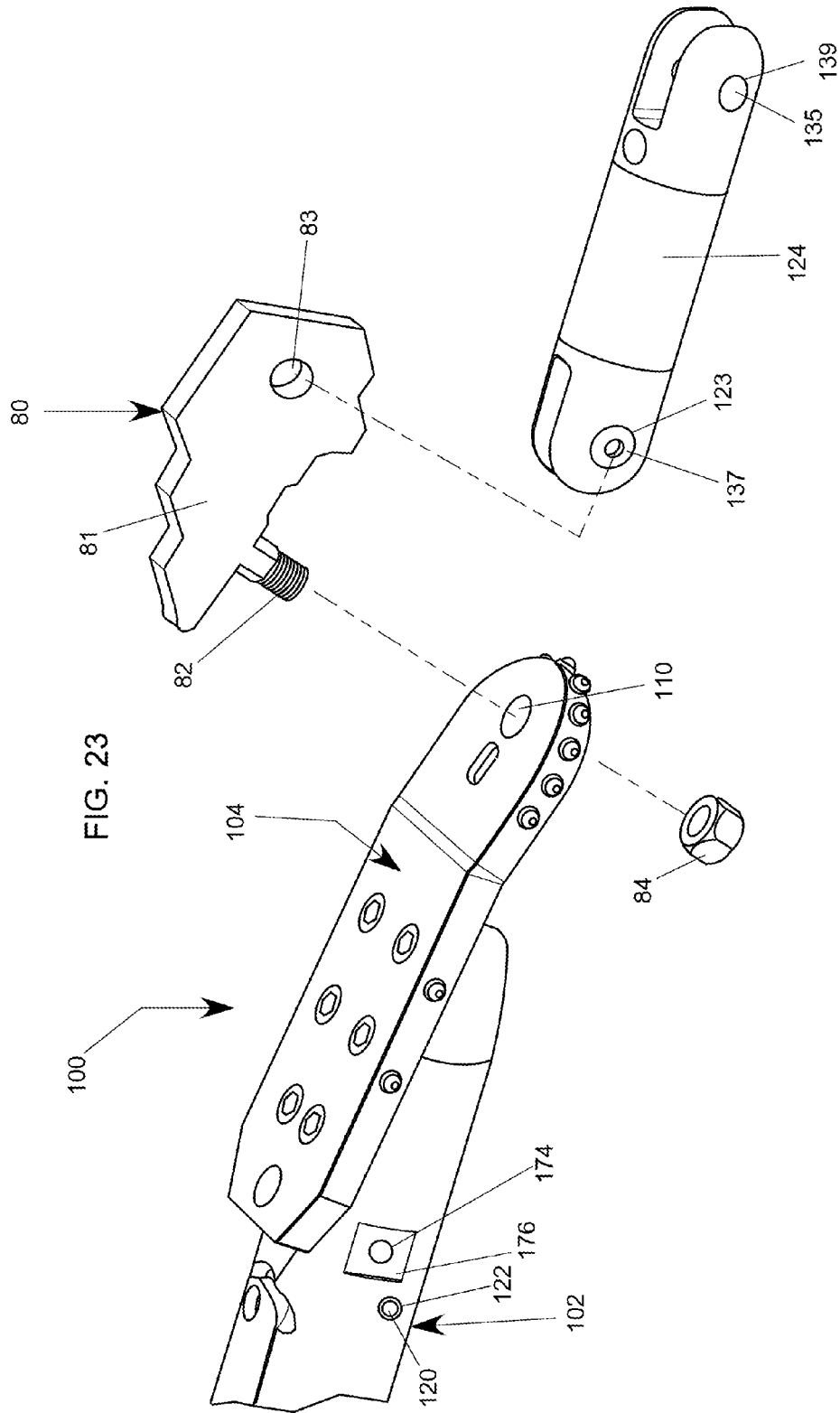


FIG. 22





DIRECT PULLBACK DEVICES AND METHOD OF HORIZONTAL DRILLING

This application is a continuation of U.S. application Ser. No. 14/181,545, filed Feb. 14, 2014, for DIRECT PULLBACK DEVICES AND METHOD OF HORIZONTAL DRILLING, which is incorporated in its entirety herein by reference.

FIELD

Devices and methods for use in underground drilling are described, and in particular, devices and methods for pilot bore and direct pullback operations in horizontal directional drilling.

BACKGROUND

Horizontal Directional Drilling (HDD) is a construction method alternative to open trenching that is used for installing conduits such as cables, pipes, and the like for underground utilities. In many HDD projects, a "pilot bore" is first made using a steerable drilling tool, typically consisting of a sonde housing, which may contain tracking electronics, a thread adapter and some type of drill bit. The drill bit is typically either a flat "paddle bit" or an "offset rock bit." This combination of sonde housing, thread adapter and drill bit may be referred to as the "drill head assembly." Typically, the thread adapter of the drill head assembly is connected to a string of drill rods. The drill rods may be 10'-15' in length and hollow with threaded ends. During pilot bore operations, the drill rods may be added to the drill string, one at a time, as the pilot bore proceeds further. The drill string may rotate to cut the soil and drilling fluid may be pumped through the drill rod and into the drill head assembly.

Typically, high pressure drilling fluid is pumped from the front of the housing or bit, in the general direction of the bore path, to aid in cutting the soil and steering. For most HDD projects, at the termination of the pilot bore, the drill head assembly is removed and a backreamer is attached. In one or more steps, the backreamer enlarges the hole to a size adequate for the pipe or conduit being installed, and drilling fluid is pumped through the backreamer to aid in the cutting of the soil, to condition the bore hole, and to provide a medium for carrying the cuttings out of the hole. The drilling fluid is typically pumped at a lower pressure and higher flow rate during backreaming than during the pilot bore drilling step. The product pipe is pulled into the reamed hole, behind the backreamer, in the "backream and pullback" step.

For installation of smaller utilities, such as telecommunication transmission lines or small gas distribution lines, the hole created by the pilot bore drilling step may be sufficiently large for the installed product pipe, without use of a backreamer. This simplifies the installation process by eliminating the need for removing the drill head assembly and attaching the backreamer. The product pipe can be attached to the drill head assembly by means such as shackles or swivels which attach to the drill bit. This is referred to as "direct pullback." It can be an effective method for installing smaller product pipes over shorter distances.

U.S. Publication No. 2002/0112890 and U.S. Pat. No. 8,122,979 describe some of the known drill bit designs including features designed for direct pullback. These documents are primarily directed to the attachment of the product pipe to the drill head assembly for direct pullback. However, current sonde housings and drill bits are not optimized for direct pullback. The drilling fluid is still pumped from the

front of the sonde housing assembly, at high pressure and low flow rate. This is disadvantageous because the hole may be relatively dry in the backreaming direction, resulting in possible difficulties pulling back the product pipe, potentially damaging it or causing the direct pullback operation to be unsuccessful. As a result, typically, only small product pipes can successfully be installed.

In addition, if the drill head assembly rotates in a relatively dry hole, friction may cause the sonde housing to become heated, potentially damaging the tracking electronics housed inside. Also, the high pressure drilling fluid jet may impinge upon the swivel, puller or product pipe, also potentially causing damage. The flow rate of drilling fluid may also be lower than desired for installation of the product pipe. Typically the drill head assembly will not ream the hole larger than it was cut during the pilot boring operation, nor will it effectively mix the soil cuttings with the drilling fluid. This further limits the diameters and lengths of the product pipe that can be installed. It would be advantageous to be able to use direct pullback for larger or multiple product pipes.

Accordingly, what is needed is a direct pullback device and method that overcome the aforementioned disadvantages associated with the known devices.

SUMMARY

The present invention satisfies such a need. In one embodiment, an apparatus for horizontal directional drilling includes an elongated housing including an interior, a front, a rear, and a longitudinal axis passing through the front and rear. The apparatus further includes a sonde transmitter mounted in the interior. A main fluid channel extends in the interior of the housing in a direction along the longitudinal axis to permit a flow of a fluid therethrough. The apparatus may include a fluid outlet proximate the front of the housing and in fluid communication with the channel and adapted to permit the fluid to flow therethrough to facilitate pilot bore drilling operations. The apparatus further includes a plurality of fluid ports in fluid communication with the main fluid channel and adapted to permit the fluid to be emitted therethrough to facilitate pullback operations. The apparatus further includes a drill bit coupled to the front of the housing, the drill bit including a plurality of drill bit cutting elements.

The apparatus may include a plurality of plugs, each one of the plugs being inserted into a respective one of the fluid ports to prevent the fluid that flows through the channel from being emitted from the housing through the fluid ports. At least one of the plugs may include an opening to permit the fluid to flow through the at least one of the plugs when the at least one of the plugs is inserted into the respective one of the fluid ports.

The apparatus may further include a connecting member coupled to the drill bit. The connecting member may be coupled to a tow head sized and shaped to receive a portion of a conduit and retain the portion of the conduit during a direct pullback operation of the apparatus. The connecting member may be coupled to the drill bit indirectly, via a connecting link including an aperture for receiving a fastener.

In one embodiment, the drill bit is attached directly to the front of the housing. The drill bit may be one of a paddle bit and an offset rock bit. The offset rock bit may include a fluid outlet in a form of a nozzle to permit the fluid to be emitted from the nozzle to irrigate soil surrounding the nozzle.

The drill bit may be coupled to a bit body that includes an adapter configured to couple to the front of the housing and

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having a fluid channel passing therethrough and terminating in an opening adapted to permit the fluid that flows through the main fluid channel of the housing to be emitted from the opening of the bit body.

In one embodiment, the apparatus includes at least one cutting block removably coupled to the housing. The at least one cutting block element includes a plurality of cutting block cutting elements extending therefrom. In one approach, the apparatus may include at least a first cutting block removably coupled to the housing and including first cutting block cutting elements defining a first outer diameter extending therefrom, and at least a second cutting block removably coupled to the housing and including second cutting block cutting elements defining a second outer diameter extending therefrom, the second outer diameter being greater than the first outer diameter. The apparatus may further include a pullback adapter mounted on the drill bit, the pullback adapter including at least one cutting element extending therefrom and having at least one opening to permit a connecting member adapted to be coupled to a tow head to be coupled to the pullback adapter.

In one embodiment, the apparatus may further include a rear adapter coupled to the rear of the housing. The rear adapter is configured to permit a fluid source to be coupled to the housing and includes a fluid passage extending in a direction along the longitudinal axis and in communication with the main water channel in the housing. In one embodiment, at least a portion of the rear adapter is received in the rear of the housing when the rear adapter is threadably coupled to the housing. The rear adapter may include a fluid channel passing therethrough, the fluid channel being in fluid communication with the main fluid channel of the housing when the rear adapter is coupled to the housing. The rear adapter may also include at least one fluid port in fluid communication with the fluid channel of the rear adapter and adapted to permit the fluid to be emitted through the at least one fluid port of the rear adapter.

In one embodiment, a pullback adapter for attachment to a horizontal drilling apparatus includes a body including an opening for permitting a fastener to pass therethrough and first and second arms extending from the body. The first and second arms may include at least one cutting element extending therefrom adapted to cut through soil and opposed interior flat portions adapted to permit the first and second arms of the pullback adapter to slide over corresponding flat portions of the horizontal drilling apparatus. At least one of the first and second arms including at least one aperture adapted to permit a fastener to pass therethrough to attach the pullback adapter to the horizontal drilling apparatus. The at least one aperture of the pullback adapter may be positioned between two adjacent cutting elements.

In one embodiment, a cutting block for attachment to a horizontal drilling apparatus is provided. The cutting block includes a body including at least one cutting element extending therefrom and adapted to cut through soil. The cutting block further includes first and second arms extending from the body. The first and second arms include opposed interior flat portions adapted to permit the first and second arms of the cutting block to slide over corresponding flat portions of a housing of the horizontal drilling apparatus. At least one of the first and second arms may include at least one aperture adapted to permit a fastener to pass therethrough to attach the cutting block to the housing of the horizontal drilling apparatus. The at least one cutting element of the cutting block may include a plurality of cutting elements that are incrementally increased in size.

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In an alternative embodiment, an apparatus for direct pullback during horizontal directional drilling includes: an elongated housing including an interior, a front, a rear, and a longitudinal axis passing through the front and rear; a sonde transmitter mounted in the interior;

a main fluid channel to permit a flow of a fluid therethrough, the channel extending in the interior of the housing in a direction along the longitudinal axis; a fluid outlet at the front of the housing, the fluid outlet being in fluid communication with the channel and adapted to permit the fluid to flow therethrough such that the fluid is emitted from the front of the housing; a plurality of fluid ports in fluid communication with the main fluid channel and adapted to permit the fluid to be emitted from the housing through the fluid ports, at least one of the fluid ports being at least in part obstructed by a removable fluid plug; a rear adapter coupled to the rear of the housing, the rear adapter configured to permit a fluid source to be coupled to the housing, the rear adapter including a fluid passage extending in a direction along the longitudinal axis and in communication with the main water channel in the housing; a drill bit coupled to the front of the housing, the drill bit including a plurality of drill bit cutting elements; a connecting member indirectly coupled to the drill bit via one of a connecting link and a pullback adapter such that the connecting member is securely attached to the drill bit with a central longitudinal axis of the connecting member being generally aligned with a central longitudinal axis of the housing; and a tow head coupled to the connecting member such that the tow head is permitted to swivel relative to the connecting member, the tow head being sized and shaped to receive a portion of a conduit and retain the portion of the conduit during a direct pullback operation of the apparatus.

In one preferred embodiment, a method of horizontal directional drilling includes: advancing, through a soil in a first direction, an elongated housing including a drill bit with a plurality of drill bit cutting elements and a nozzle at a front of the housing adapted to emit a fluid proximate the front of the housing to wet the soil and an at least one fluid outlet along a length of the housing adapted to emit the fluid along the length of the housing, the at least one fluid outlet being obstructed by a removable fluid plug; attaching a connecting member to indirectly to the drill bit via one of a connecting link and a pullback adapter, the one of the connecting link and the pullback adapter being securely fastened to the drill bit; attaching a tow head to the connecting member such that the tow head, when attached, is permitted to swivel relative to the connecting member; coupling a conduit to the tow head; attaching at least one cutting block to the housing; removing the fluid plug from the at least one fluid outlet; pulling the housing in a direction opposite to the first direction; and emitting, during the pulling of the housing in a direction opposite to the first direction, one or more jets of fluid from the at least one fluid outlet.

The drill head assemblies described therein provide numerous advantages over the presently used systems and methods. One advantage is that the drill head assemblies described herein advantageously lubricate the soil around the housing during direct pullback operations. Another advantage is that embodiments of the drill head assemblies described herein are configured to drill a hole of one diameter during the pilot bore drilling operation and to drill a hole of a larger diameter when passing through the same location during the direct pullback operation. Yet another advantage is that the fluid flow around the housing of the drill head assembly provides a cooling effect to the housing and to the transmitter installed in the housing, thereby

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protecting the transmitter from being overheated during the direct pullback operations. Further advantages will be appreciated by those of ordinary skill in the art with reference to the following drawings, detailed description, and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a top plan view of one embodiment of a drill head assembly for HDD drilling, configured for pilot boring with a paddle bit, shown in partial cross-section to show some of the internal structural elements of a housing of the drill head assembly;

FIG. 2 is a side elevational section view taken along line 2-2 of FIG. 1;

FIG. 3 is an isometric view of an embodiment of a drill head assembly for HDD drilling, configured for pilot boring with an offset rock bit;

FIG. 4 is an isometric view of the drill head assembly for HDD drilling of FIG. 1, including attachments configured for direct pullback operations;

FIG. 5 is an isometric view of a drill head assembly for HDD drilling of FIG. 3, including attachments configured for direct pullback operations;

FIG. 6 is an isometric view of the drill head assembly for HDD drilling of FIG. 4, including cutting block attachments coupled to a housing of the drill head assembly;

FIG. 7 is the same view as in FIG. 6, including partially exploded views to show how the cutting block attachments couple to the housing of the drill head assembly of FIG. 6;

FIG. 8 is an isometric view of an embodiment of a drill head assembly for pullback operations with an offset rock bit including partially exploded cutting blocks, pullback adapter, and rear adapter;

FIG. 9 is an enlarged perspective view of the offset rock bit of FIG. 8, with a partial exploded view to show the coupling of the pullback adapter to the offset rock bit;

FIG. 10 is an enlarged perspective view of a cutting block according to an alternative embodiment;

FIG. 11 is a perspective view of an embodiment of a drill head assembly including a paddle bit coupled to a connecting link and incorporating two cutting blocks as shown in FIG. 10;

FIG. 12 is a top plan view of an embodiment of the optional rear adapter configured for coupling to a housing of a drill head assembly;

FIG. 13 is a side elevational section view of the optional rear adapter of FIG. 12, taken along line 13-13 of FIG. 12;

FIG. 14 is a side elevational view of a drill bit body and paddle bit according to one embodiment;

FIG. 15 is a top plan view of the drill bit body and paddle bit of FIG. 14;

FIG. 16 is a side elevational section view of the drill bit body and paddle bit of FIGS. 14-15, taken along line 16-16 of FIG. 15;

FIG. 17 is a top plan view of one embodiment of the housing of the drill head assembly of FIG. 8;

FIG. 18 is a side elevational sectional view of the housing of FIG. 17 taken along line 18-18;

FIG. 19 is a side elevational view of one embodiment of a plug for insertion into a fluid port in a housing of a drill head assembly.

FIG. 20 is a side elevational sectional view of the plug of FIG. 19 taken along line 20-20;

FIG. 21 is a side elevational view of another embodiment of a plug for insertion into a fluid port in a housing of a drill head assembly;

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FIG. 22 is a side elevational sectional view of the plug of FIG. 21 taken along line 22-22; and

FIG. 23 is an enlarged partial view of a front end of the drill head assembly of FIG. 1, showing an exploded view of a connecting link connectable to the drill bit and a swivel connector connectable to the connecting link.

DETAILED DESCRIPTION

Reference will now be made in detail to the present preferred embodiments of the invention, examples of which are illustrated in the accompanying drawings.

Generally, what is disclosed is an improved drill head assembly for horizontal directional drilling that improves performance and capability during direct pullback operations. FIG. 1 shows one embodiment of a drill head assembly 100 for HDD drilling, and more specifically, for pilot boring operations using an HDD rig and drill rods. The drill head assembly 100 includes an elongated housing 102. The housing 102 is shown as being generally cylindrical, but may be of any other suitable shape. The housing 102 has a front portion or front 103 and a rear portion or rear 105, and a length therebetween. A longitudinal axis passes through the front and rear 103, 105 of the housing 102, along the length. An exemplary longitudinal axis may coincide with the horizontal portion of the line 2-2 of FIG. 1.

A "sonde" electronic transmitter 112 is mounted to the housing 102 and located in an interior 101 of the housing 102. The sonde transmitter 112 is equipped with electronics (e.g., radio frequency transmitter) that permit the location of the sonde transmitter 112 to be identified while the transmitter 112 is underground. In the illustrated form, the transmitter 112 is retained in the interior 101 of the housing 102 by a lid 106. The lid 106 may be retained in a closed position, for example, by one or more bolts 141 and may be removed from the closed position shown in FIG. 2, where the lid 106 retains the transmitter 112 in the housing 102 and restricts access to the transmitter 112, such that access to the transmitter 112 is permitted, for example, for maintenance, removal, or other operations. The lid 106 and sonde 112 in FIG. 2 are conventional and any suitable sonde or lid may be used with the housing 102. For proper operation of the transmitter 112, it is preferable that the transmitter 112 is kept at temperatures not exceeding 100° C.

An optional rear adapter 108 may be removably (e.g., threadably) attached at the rear 105 of the housing 102, as shown in FIG. 1. The rear adapter 108 may be used to permit a drill rod (or other tools) to be coupled (e.g., via threads or an interference fit) to the housing 102. The drill rods (not shown) are preferably added by an operator at the HDD rig to a drill string, one at a time (e.g., end-to-end via a threaded connection), during pilot bore drilling operation, to incrementally extend the length of the pilot bore made by the drill head assembly 100. It will be appreciated that a drill rod alternatively may be coupled (e.g., via a threaded connection) to the rear of the housing 102 directly, without the use of the optional rear adapter 108. The drill rods are preferably coupled to a fluid source, such that when a drill rod in a series of interconnected drill rods is coupled to the housing 102 of the drill head assembly 100 (with or without the use of the optional rear adapter 108), the drill rod provides fluid to be pumped through the housing 102 to assist in wetting and softening the ground around the drill head assembly 100.

The optional rear adapter 108 is shown in more detail in FIGS. 12 and 13. With reference to FIG. 12, the exemplary optional rear adapter 108 has a front end 115, a rear end 117,

a length therebetween, and a longitudinal axis passing through the front and rear ends **115**, **117**. An exemplary longitudinal axis may coincide with the horizontal portion of the line **13-13** of FIG. **12**. The rear adapter **108** includes a rear portion **109** with a top surface **119** and a bottom surface **121** and a front portion **111** with a top surface **123** and a bottom surface **129**. In the embodiment illustrated in FIGS. **12-13**, the top and bottom surfaces **123**, **129** of the front portion **111** of the rear adapter **108** include threads **163** adapted to threadably attach the optional rear adapter **108** to the housing **102** of the drill head assembly **100**. In the illustrated embodiment, the top and bottom surfaces **119**, **121** of the rear portion **109** of the optional rear adapter **108** are straight and parallel to each other, while the top and bottom surfaces **123**, **129** of the front portion **111** are straight and converge toward each other in a direction from the rear end **117** to the front end **115** of the rear adapter **108**. It will be appreciated that the top and bottom surfaces **119**, **121**, **123**, **129** of the front and rear portions **109**, **111** may have various shapes (at least in part curved, zigzagged, undulating, etc.) and orientations relative to each other and may be non-parallel, diverging, parallel, or converging relative to one another.

In the illustrated form, the rear **105** of the housing **102** has an open area or recess **107** for receiving a portion of the rear adapter **108**, more specifically, the front portion **111** of the rear adapter **108**. As discussed above, preferably, the rear adapter **108** includes threads **163** at top and bottom surfaces **123** and **129** and the rear **105** of the housing **102** includes threads **173** corresponding to the threads of the rear adapter **108** such that the rear adapter **108** and the rear **105** of the housing **102** can be threadably coupled such that at least a portion of the rear adapter **108** is received in the recess **107** at the rear **105** of the housing **102**, as shown in FIG. **2**. While the rear adapter **108** is coupled to the rear of the housing **102** via a threaded connection in the illustrated form, it will be appreciated that any suitable connection other than a threaded connection may be used, for example, a spline and pin, an interference fit, or a friction fit, or one or more fasteners. It is to be appreciated that instead of being removably attached to the housing **102**, the optional rear adapter **108** may be formed a part of the structure of the housing **102** such that the rear adapter **108** and the housing **102** form a unitary monolithic structure.

The housing **102** includes a main fluid passage or channel **114** and a fluid outlet **116** that is in communication with the channel **114**. It will be appreciated that instead of having a single channel **114**, the housing **102** may optionally include two or more such channels. The channel **114** extends in a direction along the longitudinal axis of the housing **102** along a majority of the length of the housing **102** as shown in FIG. **2**, and may pass through the entire length of the housing **102**. The channel **114** may extend such that the recess **107** at the rear **105** of the housing **102** is in fluid communication with the fluid outlet **116** via the channel **114**, as shown in FIG. **2**. The fluid outlet **116** is located at the front **103** of the housing **102** and is adapted to permit a fluid (e.g., water or bentonite slurry) that flows through the channel **114** to be emitted from the front **103** of the housing **102** through the fluid outlet **116**. In one form, the fluid outlet **116** includes one or more openings, and is preferably in the form of a nozzle adapted to permit the fluid to be emitted from the front **103** of the housing **102** in one or more jets to wet and soften up the soil in front and around the front **103** of the housing **102** of the drill head assembly **100**. As shown, for example, in FIG. **2**, the nozzle **116** is oriented in a direction along the longitudinal axis.

With reference to FIGS. **1**, **2**, and **4-7**, the housing **102** may include one or more openings defining auxiliary fluid ports **122** in communication with the main fluid passage or channel **114**. As such, a fluid flowing under pressure through the channel **114** in a direction from the rear **105** to the front **103** of the housing **102** would exit through the fluid ports **122**, if the fluid ports **122** are open. In the illustrated embodiment, the fluid ports **122** are oriented in a direction transverse both to the channel **114** and the longitudinal axis of the housing **102**. It is to be appreciated, however, the angle of the fluid ports **122** relative to the channel **114** is shown by way of example only, and that the fluid ports **122** may be oriented at a variety of orientations not transverse to the channel **114**. For example only, the fluid ports **122** may be oriented at 15°, 30°, 45°, 60°, 75°, 120°, 135°, 150°, 165°, or an other suitable orientation relative to the channel **114**. The fluid ports **122** may be located at various locations of the housing **102**. For example, one or more fluid ports **122** may be positioned at or proximate the front **103** of the housing **102** and one or more fluid ports **122** may be positioned at or proximate the rear **105** of the housing **102**, as shown by way of example in FIGS. **1-2** and **6-7**. It will be appreciated that the auxiliary fluid ports **122** can be located in components of the drill assembly **100** other than, or in addition to, the housing **102**. For example, as discussed in more detail below, the optional rear adapter **108** is shown in FIGS. **1-2**, **4-7**, and **13** as having an optional fluid port **148** which, if open (i.e., not sealed by a plug **150**), would permit fluid to exit therethrough. Further, while not shown in FIGS. **1** and **2**, FIG. **3** shows that the optional rear adapter **108** may optionally include one or more flat portions **176** each including an opening **174** similar to the flat portion **176** and openings **174** in the housing **102** to permit a cutting block **170** to be optionally attached to the optional rear adapter **108** via a fastener passing through the opening **174**.

In one embodiment, one or more plugs **120** are inserted into the fluid ports **122** to seal the fluid ports **122**. Similarly, if the optional rear adapter **108** is used, the fluid port **148** of the rear adapter **108** may be sealed by a plug **150**. In one form, the plugs **120** include threads and are threaded into the fluid ports **122**, which include corresponding threads to permit a threaded coupling of the plugs **120** to the ports **122**. The attachment of the plugs **120** to the ports **122** to partially and/or fully obstruct and partially and/or fully seal the ports **122** may be used in pilot boring operation. For example, during pilot boring operation, a high pressure drilling fluid is pumped through the channel **114** of the housing **102**. Since the fluid ports **122** are blocked by the plugs **120**, the fluid is prevented from being emitted through the ports **122**. Instead, the fluid flowing through the channel **114** is ejected in one or more high pressure jets **118** through the nozzle **116** located at the front **103** of the housing **102**. The fluid jets **118** facilitate the steering of the drill head assembly **100** through the pilot bore and the cutting of the soil ahead of a paddle bit **104** attached to the housing **102**, which will be described in more detail below.

One exemplary plug **120** that includes exterior threads **145** and an interior recess including edges **147** shaped to mate with an end of a tool (e.g., a hex key), and which may be used to block the fluid ports **122** of the housing **120** is shown in FIGS. **19** and **20**. In one approach, during direct pullback operations, the plugs **120**, which are preferably solid and do not have a through hole as shown in FIG. **20**, may be replaced with pre-drilled fluid plugs **620** as shown in FIGS. **21** and **22**. As shown, for example, in FIG. **22**, such pre-drilled plugs **620** may also include exterior threads **645** and a recess including hex-shaped (or alternatively shaped)

interior edges **647** and may be provided with one or more through holes **649** of various sizes, to permit a drilling fluid flow rate to be adjusted to suit the needs of almost any horizontal directional drilling installation. Also, during direct pullback, one or more undrilled plugs **620** may be left in the fluid ports **122** to regulate the amount of drilling fluid flow rate and the location(s) where the drilling fluid is discharged from the housing **102**. Alternatively, for direct pullback operations, the solid plugs may be removed and not replaced to permit drilling fluid to be emitted through the entire opening of the fluid ports **122**.

In one optional embodiment, the rear adapter **108** includes one or more auxiliary fluid ports **148**, as shown in FIGS. **2** and **13**. Such fluid ports **148** in the rear adapter **108** may provide an additional benefit by allowing drilling fluid flow near the very rear of the drill head assembly **100**, facilitating the direct pullback operation. As shown in FIG. **13**, the fluid ports **148** of the rear adapter **108** are in fluid communication with a fluid passage or second channel **152**, which in turn may be in fluid communication with the main fluid passage or first channel **114** of the housing **102** when the rear adapter **108** is coupled to the housing **102**. As shown in FIG. **13**, the fluid ports **148** of the rear adapter **108** may be at least partially obstructed and/or sealed by plugs **150** similar to the plugs **120** or **620** described above. At least partially obstructing and/or sealing the fluid ports **148** with the plugs **150** may be useful during pilot bore operations for the same reasons as at least partially obstructing and/or sealing the fluid ports **122** of the housing **102** with the plugs **120** is useful during pilot bore operations, as described above.

To permit a drill rod (not shown) to be coupled to the drill head assembly **100**, the rear adapter **108** includes an open area or opening **153** adapted to receive and couple to a portion (e.g., an end) of the drill rod. The drill rod may be in turn connected via one or more additional interconnected drill rods that may be attached end-to-end and/or positioned over a drill string to a water source such as a water hose. In the embodiment illustrated in FIGS. **2** and **13**, the opening **153** of the rear adapter **108** includes threads **161** that permit a lead end of the drill rod to threadably couple to the rear adapter **108**. Since the opening **153** is in fluid communication with the channel **152** of the rear adapter **108**, a fluid flowing through the drill rod may flow through the channel **152** of the rear adapter **108** and through the channel **114** of the housing **102** towards the nozzle **116** as described above.

In one illustrated embodiment, for example, in FIGS. **1**, **2**, **4**, and **6-8**, a paddle bit **104** is attached to the housing **102** at the front **103** of the housing **102**. As shown, for example, in FIGS. **2** and **8**, the paddle bit **104** has a front end **151**, a rear end **153** opposite the front end **151**, and a plurality of teeth or projections or drill bit cutting elements **155** extending from the paddle bit **104** and adapted for cutting through soil to permit forward movement of the drill assembly **100** during pilot bore operations. At the front end **151** of the paddle bit **104**, the paddle bit **104** may include a through hole or opening **110**. The opening **110** permits attachment of a swivel arm assembly **124** or a pulling link (**80**), as described below. At the rear end **153**, the paddle bit **104** may include an opening **113** that may, in one embodiment, permit access to a bolt **141** that retains the lid **106** in the closed position. In embodiment illustrated in FIGS. **1-2**, the paddle bit **104** is attached directly to housing **102** at the front **103** of the housing **102**, via fasteners **143** (six fasteners **143** are shown by way of example only, but the number of fasteners may vary) such as bolts or pins. The paddle bit **104** does not have to be attached directly to the housing **102** and may be

attached via an intermediate connector or drill bit adapter assembly **154**, as shown in FIG. **14-16** and described below.

FIGS. **14-16** illustrate an exemplary embodiment of a drill bit adapter assembly **154** that may be used to permit attachment of the paddle bit **104** to a housing **302** of the drill head assembly **300** as shown in FIGS. **17-18**. The housing **302** of the drill head assembly **300** is similar to the housing **302** of the drill head assembly **100** and is labeled with like reference numerals, but unlike the housing **102**, which has a front end **103** that lacks a threaded recess area adapted to receive a threaded adapter portion **136** of a drill bit adapter assembly **154**, the front end **303** of the housing **302** of the drill head assembly **300** includes an open or recess area **367** that includes threads **369** as shown in FIG. **18** that permit the threaded adapter portion **136** of the adapter assembly **154** to be threadably and removably secured to the front end **303** of the housing **302**. The bit adapter assembly **154** includes a bit adapter or bit body **156**, which is preferably cylindrical, but which may be of any other suitable shape, as shown in FIG. **16**.

A drill bit **104** may be removably or non-removably coupled to the bit body **156** of the bit adapter assembly **154**. For example, the drill bit **104** may be mounted on top of the bit body **156** and secured via fasteners **143** (six fasteners **143** are shown by way of example only, but the number of fasteners may vary), as shown, for example, in FIG. **16**. Alternatively, the drill bit **104** may be optionally made as a monolithic unitary structure with the bit body **156**.

The bit body **156** further includes an adapter portion **136** at a rear **139** of the bit body **156**. The adapter portion **136** may be integrally formed as a part of a unitary monolithic structure with the bit body **156**, or may be non-removably, or removably attached (e.g., via a threaded connection) to the bit body **156**. The adapter portion **136** is sized and shaped (e.g., frusto-conical) to be inserted into, and mate with a complementary-shaped (e.g., frusto-conical) recess area **367** at the front **303** of the housing **302** of the drill head assembly **300**. For example, the adapter portion **136** preferably includes threads **138**, but may be attached via one or more fasteners (e.g., bolts, pins, or the like) to the front **303** of the housing **302**.

At a front **137** of the bit body **156**, the bit body **156** has a fluid passage or channel **164** and a fluid outlet **158** in communication with the channel **164**. The channel **164** extends in a direction along the longitudinal axis of the bit body **156** and may pass through the entire length of the bit body **156**. The opening or fluid outlet **158** may be in the form of a nozzle that permits a fluid to exit the fluid outlet **158** in the form of a jet, for example, during pilot bore drilling operations. The exemplary bit body **156** of FIG. **16** may optionally also include one or more auxiliary fluid ports **162** in communication with the channel **164** and fluid plugs **160** similar to the plugs **120**, **150**, or **620** described above for at least partially obstructing and/or sealing the fluid ports **162**, which may be removed when appropriate, for example, during direct pullback operations.

FIG. **3** illustrates one embodiment of a drill head assembly **300** in a form configured for pilot boring operation. The drill head assembly **300** includes a housing **302** and, instead of a paddle bit **104** as described above, includes an offset rock bit **200** attached to the housing **302**. The offset rock bit **200** is preferably attached to the housing **302** by being threaded directly into the threads **369** of the recess area **367** (see, e.g., FIG. **18**) at the front **303** of the housing **302**. More specifically, the exemplary rock bit **200** includes an adapter portion **236** including threads **238** that permit the threaded adapter portion **236** of the offset rock bit **200** to be thread-

ably and removably secured to the front end **303** of the housing **302**. It will be appreciated that instead of being threaded into the housing **302** of the drill head assembly **300**, the offset rock bit **200** may be optionally modified for attachment to a housing such as the housing **102** via one or more fasteners such as bolts. As shown in FIGS. **3** and **17-18**, similar to the housing **102**, the housing **302** includes one or more openings defining auxiliary fluid ports **322** in communication with a main fluid passage or channel **314** passing through the interior of the housing **302**. As such, as described above, a fluid flowing under pressure through the channel **314** passing through the interior of the housing **302** would exit through the fluid ports **322**, if the fluid ports **322** are open and not obstructed or sealed by removable plugs **320**, which may be similar to plugs **120** or **620** described above.

With reference to FIG. **3**, the offset rock bit **200** has a front end **251**, a rear end **253** opposite the front end **251**, and a plurality of teeth or projections **255** extending from the offset rock bit **200** and adapted for cutting through soil to permit forward movement of the drill assembly **300** during pilot bore operations. At the front end **251** of the offset rock bit **200**, the offset rock bit **200** may include one or more openings or fluid ports **210**. During pilot bore drilling operations, high pressure drilling fluid is ejected through the fluid ports **210** in high pressure jets **118** from the front end **251** of the offset rock bit **200**, softening the soil around the offset rock bit **200** to facilitate the pilot boring operations.

Upon completion of the pilot bore, the drill head assemblies **100**, **300** may be reconfigured for direct pullback operations. In one embodiment shown in FIG. **4**, a swivel connector or connecting member **124** is attached to the paddle bit **104**. The connecting member **124** has a front end **131** including an aperture **139** that permits attachment of a tow head or duct puller **126** configured to retain and pull a conduit **127** (e.g., pipe, cable, or the like) during direct pullback operations. The connecting member **124** has a rear end **133** including an aperture **137** that permits the rear end **133** of the connecting member **124** to be securely fastened (directly or indirectly, as described below) to the paddle bit **104**.

For example, in the form illustrated in FIG. **4**, the rear end **131** of the swivel connector **124** may be securely fastened directly to the front end **151** of the paddle bit **104** via an attachment member **123**. The attachment member **123** may be a bolt or pin that passes through the opening **110** in the paddle bit **104** and through the opening **137** in the swivel connector **124**, as shown in FIGS. **4**, **6**, and **7**. The bolt, pin, or other fastener **123** may be secured by a nut **157** or the like on an opposite side of the paddle bit **104**. The connecting member **124** is thus securely (e.g., rigidly, or non-movably) attached to the to the paddle bit **104** via the fastener **123**. Preferably, the swivel connector **124** is securely attached to the paddle bit **104** such that a longitudinal axis of the swivel connector **124** is generally aligned with the longitudinal (e.g., central) axis of the housing **302**, which restricts the swivel connector **124** from flopping over or jack knifing.

Alternatively to connecting the swivel connector **124** directly to the paddle bit **104**, a connecting link **80** may be used to indirectly attach the swivel connector **124** to the paddle bit **104**. For example, FIG. **23** shows an embodiment where a connecting link **80** is used to attach the swivel connector **124** to the paddle bit **104**. The exemplary connecting link **80** includes a body **81**, a threaded attachment member **82** extending downwardly from the body **81**, and an opening **83** passing through the body **81**. FIG. **11** shows an embodiment of an exemplary drill head assembly **400**

including a housing **402** and a paddle bit **104** attached to the housing **402** via a threaded connection of the bit body adapter **154** and including the optional connecting link **80**.

In the embodiment illustrated in FIGS. **11** and **23**, the connecting link **80** is attached to the paddle bit **104** by way of the threaded attachment member **82** passing through the opening **110** in the paddle bit **104** and securely tightening a nut **84** onto the attachment member **82** such that the connecting link is securely attached to the paddle bit **104** and preferably (but not necessarily) restricted from swiveling about a central axis of the opening **110**. With the connecting link **80** being securely attached to the paddle bit **104**, the swivel connector **124** may be attached to the connecting link **80** by passing a fastener **123** such as a bolt or a pin through an opening **137** of the swivel connector **124** and through the opening **83** of the connecting link **80** to securely attach the swivel connector **124** to the connecting link **80** as generally shown in FIGS. **11** and **23**. While the connecting link **80** has been shown with an opening **83** to permit the swivel connector **124** to attach to the connecting link **80**, it will be appreciated that the connecting link **80** may include any other suitable means for connecting the swivel connector **124** to the connecting link **80**, for example an elongated threaded connector. Preferably, the swivel connector **124** is securely attached to the connecting link **80** such that the longitudinal axis of the swivel connector **124** remains generally aligned with the longitudinal (e.g., central) axis of the housing **302**, which restricts the swivel connector **124** from flopping over or jack knifing.

With the swivel connector **124** connected to the paddle bit **104** as shown in FIGS. **6** and **7** or to the connecting link **80** as shown in FIG. **11**, a tow head or duct puller **126**, which is sized and shaped (e.g., cylindrical) to retain an end of a conduit **127** during direct pullback operations, may be attached to the swivel connector **124** via a fastener **135**, as shown in FIGS. **4** and **6**. The fastener **135** may be a bolt or pin that passes through the opening **139** in the connecting member **124** and through a corresponding opening in the tow head **126**, as shown in FIGS. **6-7**. Alternatively, a connecting link or shackle may be used to attach the tow head **126** to the swivel connector **124**. In the form illustrated in FIGS. **6** and **7**, the conduit **127** being retained by the tow head **126** during direct pullback operations is in the form of a pipe, but it is to be appreciated that the tow head **126** may be sized and shaped to receive and retain a cable, or any other conduit that is suitable for underground installation.

For direct pullback operations, one or more fluid plugs **120**, **320** may be removed from the auxiliary fluid ports **122**, **322** in the housing **102**, **302** of the drill head assembly **100**, **300**. Similarly, if the optional rear adapter **108** is used, one or more plugs **150** may be removed from the fluid port **148** of the rear adapter **108**. In the preferred embodiment, the auxiliary fluid ports **122**, **322** in the housings **102**, **302** (and the optional auxiliary port **148** in the rear adapter **108**) have a larger diameter than the opening in the fluid outlet **116** (or the fluid port **158** of the bit body adapter **154**, or the fluid port **210** of the rock bit adapter **200**). As such, a during the direct pullback operations, when a pressurized fluid (e.g., via a drill rod coupled to the optional rear adapter **108**) is introduced into the housing **102**, a majority of the drilling fluid flowing through the channel **114** of the housing **102** flows out of the housing **102** through the auxiliary fluid ports **122**. Thus, the flow of the fluid from the fluid ports **122** during the direct pullback operations occurs at a higher flow rate and lower pressure than the fluid flow (jets **118**) through the nozzle **116** during the pilot boring operation described above. The drilling fluid flow through the fluid ports **122** of

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the housing 102 advantageously improves pullback operations by lubricating the soil in and around the hole in the area of the housing 102. The increased drilling fluid flow rate in the area of the housing 102 also advantageously facilitates the cooling of the electronic transmitter 112. In addition, the larger diameter of the fluid ports 122 may advantageously reduce the chance that the fluid ports 122 become clogged by sand or other particles than is the nozzle 116.

In the embodiment illustrated in FIG. 7, cutting blocks 170 are mounted to the housing 102. The cutting blocks 170 may have projections, teeth, or cutting block cutting elements 171, for example, carbide cutting elements, or hard surfacing, and enlarge the hole being drilled to a size larger than the pilot bore hole to provide an enlarged hole suitable for the diameter of the conduit (e.g., pipe, cable, etc.) 127 being installed in the hole.

In one preferred form, the housing 102 includes one or more flat portions 176 each including an opening 174 (which may or may not be threaded), and the cutting blocks 170 are shaped such that they include corresponding flat portions 179 and openings 177. Thus, the cutting blocks 170 may be positioned such that each cutting block 170 at least in part surrounds the housing 102 and the flat portions 179 of the cutting block are aligned with the flat portions 176 of the housing 102, and the openings 177 of the cutting block are aligned with the openings 174 of the housing 102 to permit a fastener 172 such as a screw or a bolt to pass through the openings 176, 177 to securely attach the cutting blocks 170 to the housing 102. Optionally, as shown in FIGS. 6-7, the rear adapter 108 may also include one or more flat portions 176 each including an opening 174 similar to the flat portions 176 and openings 174 of the housing 102 to permit an additional cutting block 170 having corresponding flat portions 179 and openings 177 to be positioned at least in part around the rear adapter 108 and securely attached to the rear adapter 108 via one or more bolts 172.

The flat portions 176 of the housing 102 and the flat portions 179 of the cutting blocks 170 advantageously retain the cutting blocks 170 in the intended place and restrict the cutting blocks 170 from inadvertently rotating relative to the housing 102 or disengaging from the housing 102. While the cutting blocks 170 and the cutting elements 171 have been shown as being identical in FIGS. 6 and 7, it is to be appreciated that any of the drill assemblies 100, 300, 400 illustrated herein may include cutting blocks 170 of different sizes, or identical cutting blocks 170 having cutting elements 171 of varying sizes, such that a first cutting block would make a hole having a first diameter as it passes through the soil, and a second cutting block 170 would make a hole having a second, greater, diameter as it passes through.

Further, while the cutting blocks 170 have been shown in FIGS. 6-7 as being attached to the housing 102 of the drill assembly 100, it will be appreciated that one or more cutting blocks 170 may be attached to the housing 302 of the drill assembly 300. In particular, as shown in FIGS. 5 and 8, the housing 302, similarly to the housing 102, also includes one or more flat portions 376 each including an opening 374 to permit one or more correspondingly sized and shaped cutting blocks 170 to be attached to the housing 302 via one or more fasteners.

FIG. 5 shows an embodiment of the drill head assembly 300 as configured for direct pullback operation. In particular, in the exemplary illustrated form configured for direct pullback operation, the offset rock bit 200 of the drill head assembly 300 is coupled to a swivel connector 224 via, for example, a connecting link 230 as shown in FIG. 5. The

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connecting link 230 may be integral to, and form a unitary structure, with the offset rock bit 200, or may be attached to the offset rock bit 200 via one or more fasteners such as bolts. It will be appreciated that the swivel connector or connecting member 224 may be directly coupled to the offset rock bit 200 instead of being coupled to the rock bit 200 via the connecting link 230. In the embodiment shown in FIG. 5, the swivel connector 224 is attached via a swivel connection to a tow head or duct puller 226, which in turn retains a conduit 127 such as a pipe in a substantially similar way as described above in reference to the swivel connector 124, tow head 126, and conduit 127 of FIG. 4.

In one preferred embodiment shown in FIG. 8, the offset rock bit 200, instead of including a connecting link 230, is coupled to an exemplary embodiment of a pullback adapter 290. In the illustrated exemplary form, the pullback adapter 290 is securely attached to the rock bit 200 and coupled to a swivel connector 224, which is securely attached to the pullback adapter 290 and is in turn swivelably coupled to the tow head 226. In the exemplary embodiment shown in FIG. 9, the offset rock bit 200 includes one or more auxiliary fluid ports 202, which may be open during direct pullback operations and at least partially obstructed and/or sealed via removable plugs 214 (which include threads 244 for threadable coupling with the fluid ports 202) during pilot bore drilling operations. The attachment of the pullback adapter 290 to the offset rock bit 200 is illustrated in more detail in FIG. 9.

With reference to FIG. 9, the exemplary pullback adapter 290 includes a first arm 291 and a second arm 292 and a link plate 293. In one form, the arms 291, 292 and the link plate 293 may form a monolithic structure wherein the arms 291 and 292 are non-detachably attached (e.g., by welding) to the link plate 293. The arms 291, 292 each include one or more teeth, barbs, or cutting elements 295, preferably, carbide cutting elements and are shaped and configured to serve a function similar to the cutting blocks 170 described above. The link plate 293 is shown as separating the first and second arms 291, 292 by way of example only, and it will be appreciated that the first and second arms 291, 292 may form an integral structure or may be attached directly to each other. The link plate 293 includes an opening 294. The opening 294 permits a swivel connector 224 as described above to be securely attached to the link plate 293 of the pullback adapter 290, for example by a fastener 296 (see FIG. 8), such as a bolt or a pin passing through the opening 294 and through the corresponding opening 123 in the swivel connector 224. While the pullback adapter has been shown with an opening 294 to permit the swivel connector 224 to attach to the pullback adapter 290, it will be appreciated that the pullback adapter may include any other suitable means for connecting the swivel connector 224 to the pullback adapter 290, for example an elongated threaded connector. The swivel connector 224 may then be attached via a swivel connection provided by a fastener 235 to a tow head 226, which in turn may be coupled to a conduit 127 such as a pipe or a cable in a substantially similar way as described above in reference to the swivel connector 124, tow head 126, and conduit 127 of FIG. 4. The fastener 235 may be a bolt or pin that passes through the opening 239 in the swivel connector 224 and through a corresponding opening in the tow head 226, as shown in FIGS. 5 and 8.

In the exemplary form illustrated in FIG. 9, the first and second arms 291, 292 of the pullback adapter 290 each include an internal flat surface 297 and a hole 298 for permitting a fastener 206 (see FIGS. 8-9) to pass there-through. As shown in FIG. 9, the pullback adapter 290 is

positioned such that the pullback adapter **290** at least in part surrounds the offset rock bit **200** and the flat surfaces **297** of the pullback adapter **290** are aligned with the flat portions **208** of the offset rock bit **200**. The openings **298** of the pullback adapter **290** are aligned with the openings **299** of the offset rock bit **200** to permit a fastener **206** such as a screw or a bolt to pass through the openings **298**, **299** to securely attach the pullback adapter **290** to the offset rock bit **200**. The flat portions **208** of the offset rock bit **200** and the flat surfaces **297** of the pullback adapter **290** advantageously retain the pullback adapter **290** and restrict the pullback adapter **290** from inadvertently rotating relative to the offset rock bit **200** or disengaging from the offset rock bit **200**.

FIG. **10** is an alternative embodiment of a cutting block **370**. The exemplary cutting block **370** includes a body **373**, multiple cutting elements **371**, preferably carbide cutting elements, attached to and extending from the body **373**, and first and second arms **375** attached to and extending from the body **373**. In the illustrated form, the cutting elements **371** are welded to the body **373** of the cutting block **370**, but the cutting elements **371** may be attached to the body **373** of the cutting block **370** by any other suitable means, for example, by being screwed in or attached via fasteners. Similarly, the arms **371**, **372** may be integrally formed with the body **373** (e.g., by welding) or may be attached to the body **373** by a fastener. In the embodiment illustrated in FIG. **10**, the arms **375** include opposed interior flat portions **379** adapted to permit the first and second arms **375** of the cutting block **370** to slide over corresponding flat portions **376** of the housing **302** of the drill head assembly **300**. One or both of the arms **375** may include an opening **377** to permit the cutting block **370** to be attached by a fastener to the housing **302** of the drill head assembly **300** or a housing of a different drill head assembly, for example, the housing **402** of the drill head assembly **400** as shown in FIG. **11**.

In the illustrated exemplary form, the cutting elements **371** of the cutting block **370** are sized, shaped, and positioned such that the cutting elements **371** incrementally increase the size of the underground hole being drilled. For example, the cutting elements **371** may or may not be identical in size and the apexes **372** of the cutting elements **371** may point in different directions and may lie on curved lines having incrementally increasing radii. It will be appreciated that the cutting elements **371** are sized and oriented as shown in FIG. **10** by way of example only and various configurations of the cutting elements may be used to accommodate for different soil conditions and to cut varying hole diameters to accommodate varying conduit diameters. For example, FIG. **11** shows an embodiment of an exemplary drill head assembly **400** including a housing **402** with a first cutter block **370a**, the cutting elements **371** of which will enlarge the hole to a first diameter, and a second cutter block **370b**, the cutting elements **371** of which will enlarge the hole to a second diameter greater than the first diameter. Such an enlargement of the diameter of the pilot bore during pullback operations advantageously facilitates the passing of the tow head **126** and the conduit **127** through the bore.

Those skilled in the art will recognize that a wide variety of modifications, alterations, and combinations can be made with respect to the above described embodiments without departing from the spirit and scope of the invention, and that such modifications, alterations, and combinations are to be viewed as being within the ambit of the inventive concept.

What is claimed is:

1. A cutting block for attachment to a horizontal drilling apparatus, the cutting block comprising:

a body including at least one cutting element extending therefrom, the at least one cutting element being adapted to cut through soil; and

first and second arms extending from the body, the first and second arms having an opening therebetween configured to permit a portion of the horizontal drilling apparatus to pass therethrough, the first and second arms including opposed portions adapted to permit the first and second arms of the cutting block to slide over corresponding portions of the horizontal drilling apparatus such that the portion of the horizontal drilling apparatus passes through the opening between the first and second arms of the cutting block and the first and second arms of the cutting block at least in part surround the portion of the horizontal drilling apparatus; and

at least one of the first and second arms including at least one fastener-receiving hole passing therethrough and adapted to permit a fastener to pass therethrough to attach the at least one of the first and second arms of the cutting block to the horizontal drilling apparatus.

2. The cutting block of claim 1, wherein the at least one cutting element includes a plurality of cutting elements that are incrementally increased in size.

3. The cutting block of claim 1, wherein the at least one cutting element is configured to enlarge a hole being drilled by the horizontal drilling apparatus.

4. The cutting block of claim 3, wherein the hole enlargement is to a size larger than a pilot bore hole.

5. The cutting block of claim 1, wherein the portion of the horizontal drilling apparatus is a portion of a housing of the horizontal drilling apparatus.

6. The cutting block of claim 1, wherein the portion of the horizontal drilling apparatus is a portion of a drill bit of the horizontal drilling apparatus.

7. The cutting block of claim 6, wherein the drill bit is an offset drill bit.

8. The cutting block of claim 7, the cutting block further comprising a tab coupled to the body of the cutting block, the tab configured to allow the cutting block to be used as a pullback adapter when the cutting block is mounted to the horizontal drilling apparatus.

9. An apparatus for horizontal directional drilling, comprising:

an elongated housing including an interior, a front, a rear, a longitudinal axis passing through the front and rear, and at least one opening for receiving a cutting block fastener;

a sonde transmitter mounted in the interior;

a main fluid channel to permit a flow of a fluid there-through, the channel extending in the interior of the housing in a direction along the longitudinal axis;

a fluid outlet at the front of the housing, the fluid outlet being in fluid communication with the channel and adapted to permit the fluid to flow therethrough such that the fluid is emitted from the front of the housing;

a plurality of fluid ports in fluid communication with the main fluid channel and adapted to permit the fluid to be emitted from the housing through the fluid ports, at least one of the fluid ports being at least in part obstructed by a removable fluid plug, whereby the apparatus is configured to adjust flow rate and flow locations to provide suitable lubrication to the housing during drilling operations;

a drill bit coupled to the front of the housing, the drill bit including a plurality of drill bit cutting elements;

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a connecting member indirectly coupled to the drill bit via one of a connecting link and a pullback adapter such that the connecting member is securely attached to the drill bit with a central longitudinal axis of the connecting member being generally aligned with a central longitudinal axis of the housing;

a tow head coupled to the connecting member such that the tow head is permitted to swivel relative to the connecting member, the tow head being sized and shaped to receive a portion of a conduit and retain the portion of the conduit during a direct pullback operation of the apparatus; and

at least one cutting block mounted to a portion of the horizontal drilling apparatus, the cutting block comprising a body including at least one cutting element extending therefrom, the at least one cutting element being adapted to cut through soil, and first and second arms extending from the body and having an opening therebetween, whereby the first and second arms of the cutting block at least in part surround the portion of the horizontal drilling apparatus.

10. The apparatus for horizontal drilling of claim 9, wherein the portion of the horizontal drilling apparatus is a portion of the housing.

11. The apparatus for horizontal drilling of claim 10, further including at least a first cutting block removably coupled to the housing and including first cutting block cutting elements defining a first outer diameter extending therefrom, and at least a second cutting block removably coupled to the housing and including second cutting block cutting elements defining a second outer diameter extending therefrom, the second outer diameter being greater than the first outer diameter.

12. The apparatus for horizontal drilling of claim 9, wherein the portion of the horizontal drilling apparatus is one of a portion of the drill bit of the horizontal drilling apparatus.

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13. The apparatus for horizontal drilling of claim 12, wherein the drill bit is an offset drill bit.

14. The apparatus for horizontal drilling of claim 13, further comprising a tab coupled to the body of the cutting block, the tab configured to allow the cutting block to be used as a pullback adapter.

15. The apparatus for horizontal drilling of claim 9, wherein the at least one cutting element of the cutting block includes a plurality of cutting elements that are incrementally increased in size.

16. The apparatus for horizontal drilling of claim 9, wherein the at least one cutting element of the cutting block is configured to enlarge a hole being drilled by the horizontal drilling apparatus.

17. The apparatus for horizontal drilling of claim 16, wherein the hole enlargement is to a size larger than the pilot bore hole.

18. The apparatus for horizontal drilling of claim 9, further comprising a rear adapter coupled to the rear of the housing, the rear adapter configured to permit a fluid source to be coupled to the housing, the rear adapter including a fluid passage extending in a direction along the longitudinal axis and in communication with the main fluid channel in the housing.

19. The apparatus for horizontal drilling of claim 18, wherein the portion of the horizontal drilling apparatus is a portion of the rear adapter.

20. The apparatus for horizontal drilling of claim 9, wherein the mounting of the cutting block includes holes in the portion of the horizontal drilling apparatus and at least one of the first and second arms including at least one fastener-receiving hole passing therethrough and adapted to permit a fastener to pass therethrough to attach the at least one of the first and second arms of the cutting block to the portion of the horizontal drilling apparatus.

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